

Single Particle Studies of Ice Crystal Residue During CRYSTAL-FACE

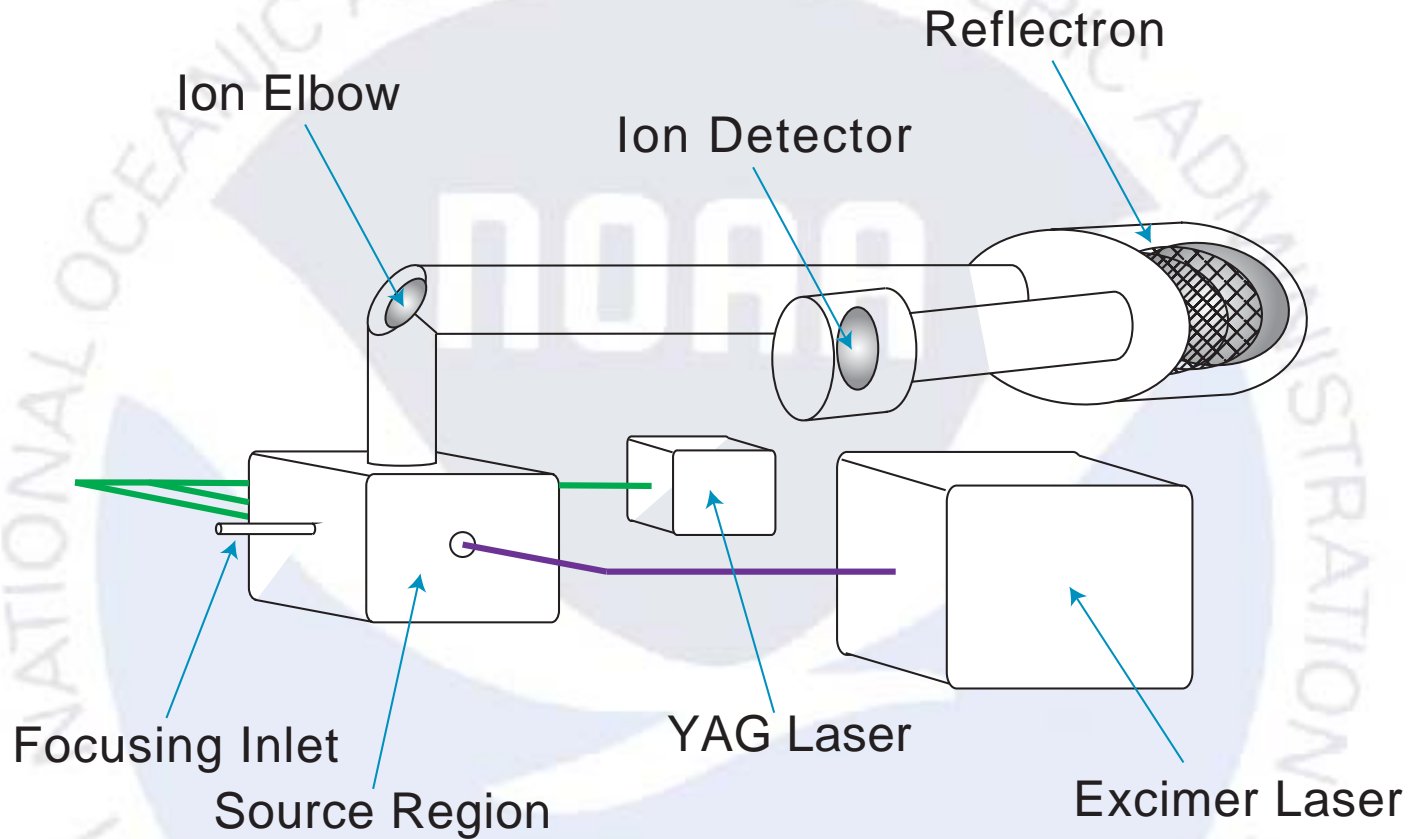
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CRYSTAL-FACE Science Team Meeting

Salt Lake City, UT

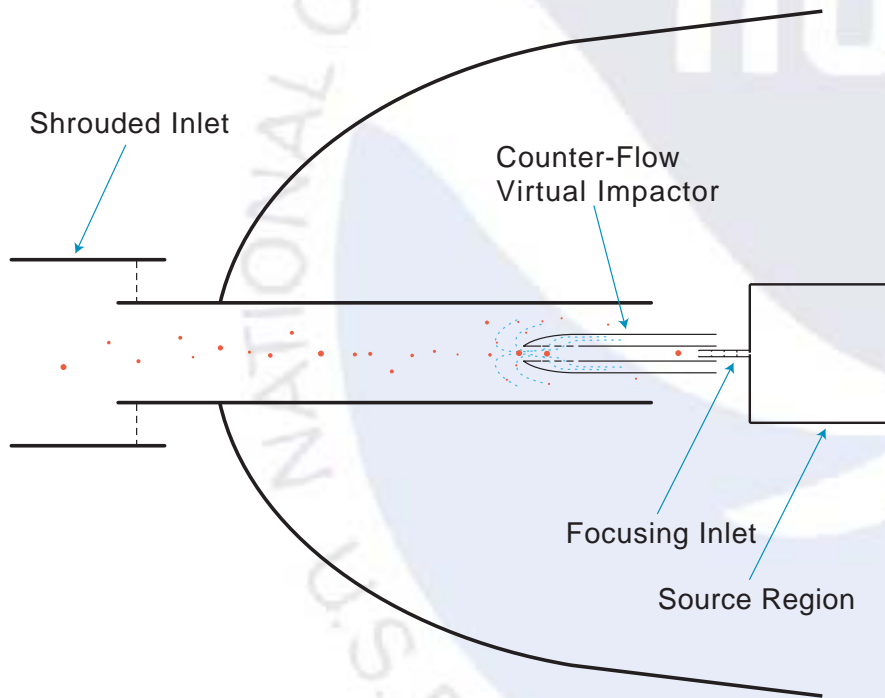
February 24-28, 2003

PALMS



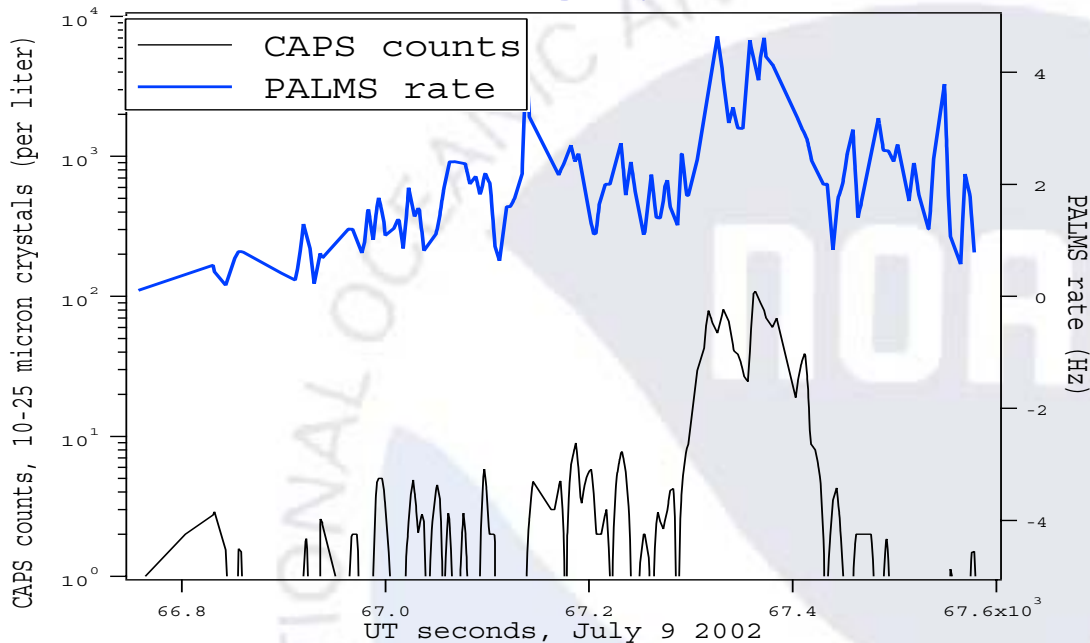
- Particles are acquired through an aerodynamic focusing inlet.
- Dual YAG laser beams are used for *particle sizing* and to trigger an excimer laser which ablates and ionizes material.
- A complete positive or negative *mass spectrum* is produced for each analyzed aerosol *0.2 - 2.0 μm* in diameter.

The CVI / PALMS Method

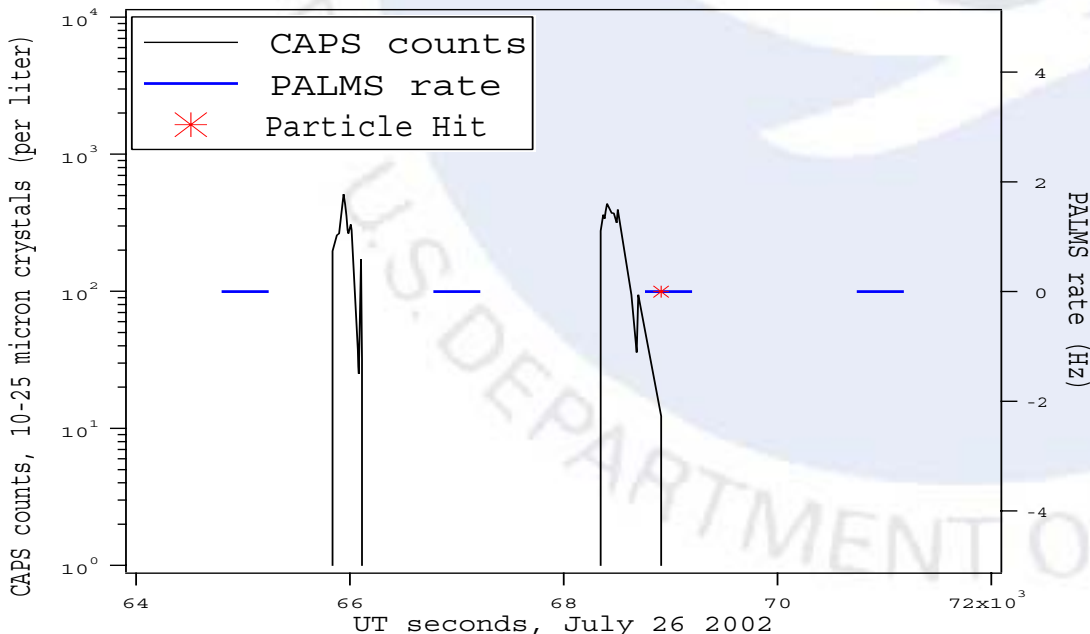


- The Counterflow Virtual Impactor (CVI) stops crystals $< \sim 7 \mu\text{m}$ diameter whereas those $> \sim 25 \mu\text{m}$ impact and are not sampled.
- Crystals are then evaporated and *ice residue* from $0.2 - 2.0 \mu\text{m}$ analyzed.
- When the CVI is not used particles $0.2 - 2.0 \mu\text{m}$ are sampled (cloud *interstitial aerosol*).
- The normal mode of operation *outside cloud* was to have no counterflow.

CVI Performance

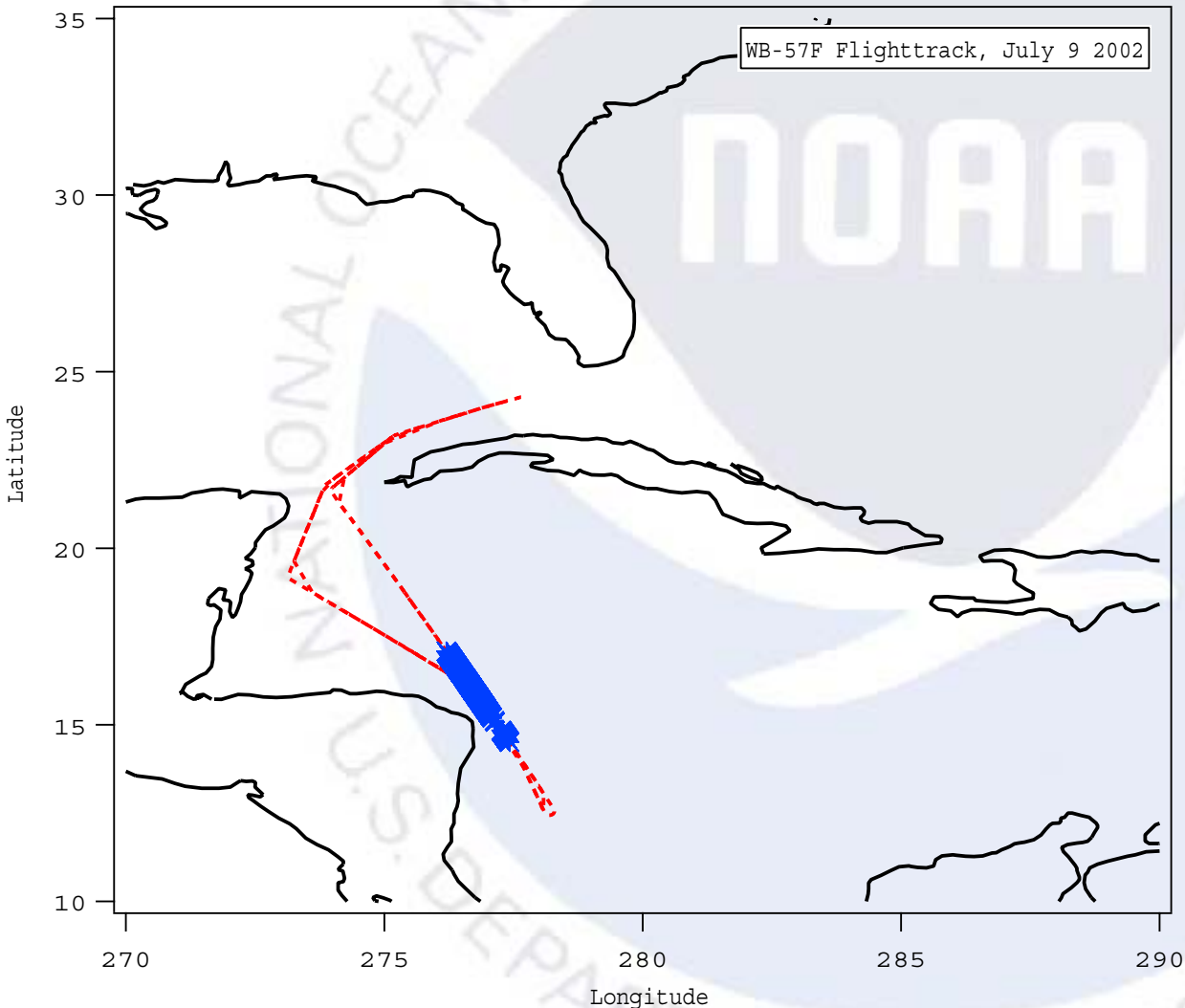


- ***Within cirrus*** rate was 1-2 Hz at ~ 5 crystals per liter (max of 5Hz).
- On 07092002 a total of 718 hits in 880 seconds CVI time = 0.85 Hz average.



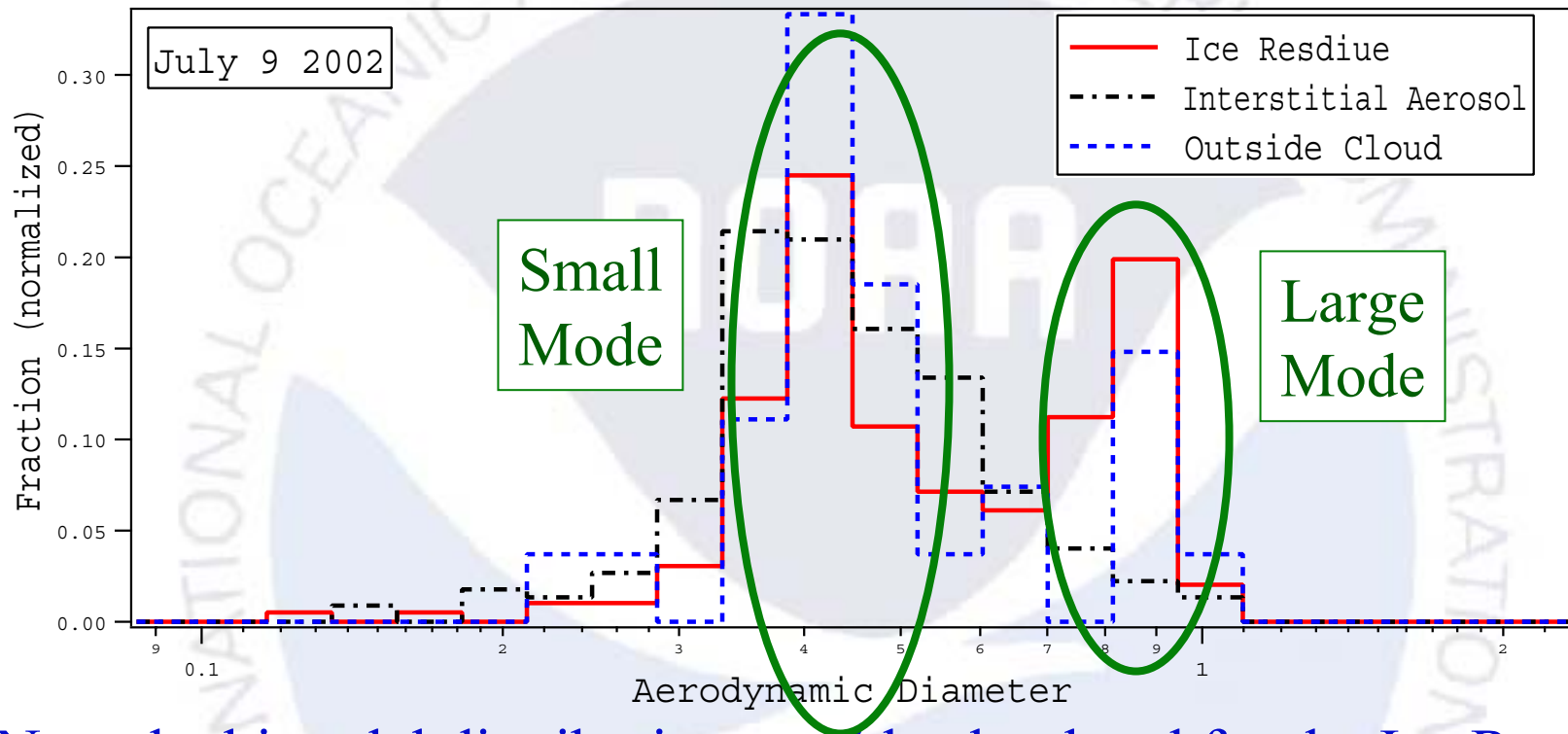
- ***Outside cirrus*** rate was ~ 0 Hz
- On 07262002 only 1 hit in 3080 seconds CVI time for CAPS counts < 1 per liter = 0.0003 Hz

Three Case Studies: 1



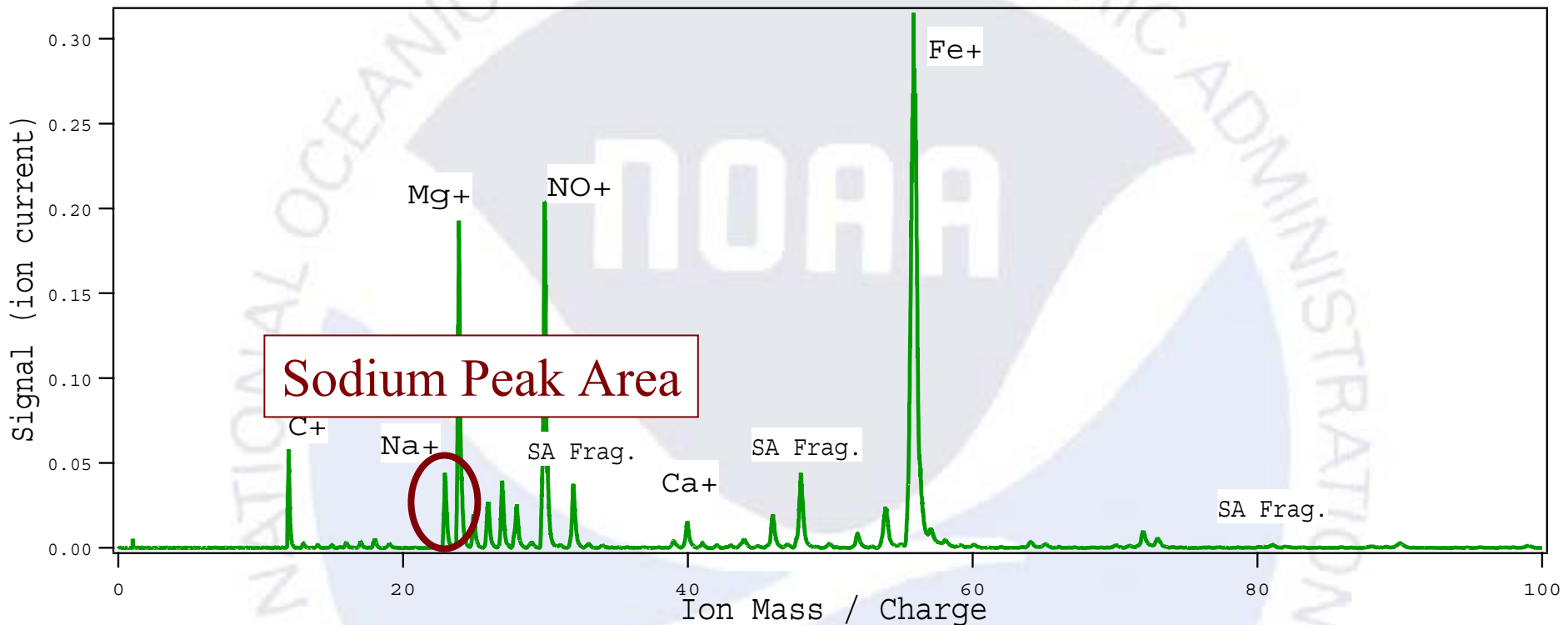
- *‘Southern Flight’* on July 9 2002.
- Cirrus just under tropopause (most data at FL 475).
- Positive and negative spectra in and out of CVI mode in the same cirrus.

Case 1: Southern Flight



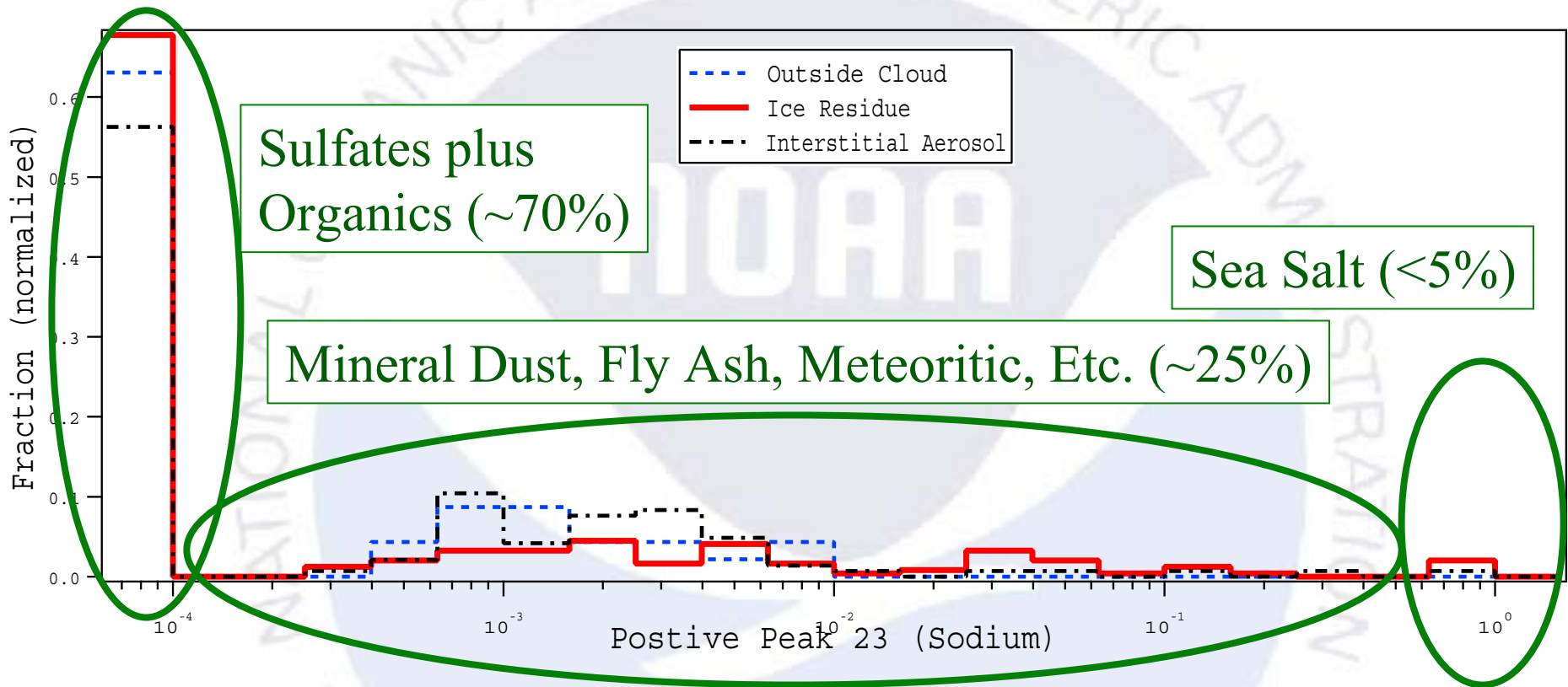
- Note the bimodal distribution outside cloud and for the Ice Residue (IR) but not in the interstitial aerosol.
- Large IR particles more varied and tropospheric in origin. Small mode is consistent with tropopause particles (I, etc.). Sulfate particles with *meteoritic material* were frozen in the cloud.
- Consistent with our understanding of *homogeneous freezing*.

Case 1: Southern Flight



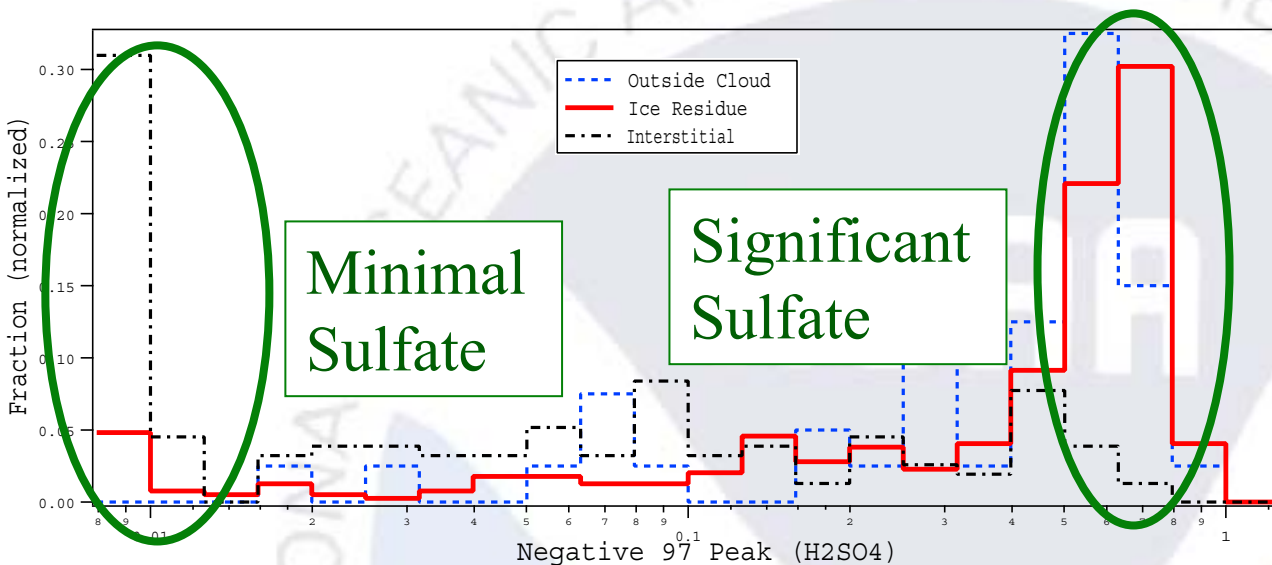
- An example of an IR which is of meteoritic origin.
- These particles are common in the stratosphere (~50%) but not in the troposphere.
- Consistent with a *stratospheric source* of particles forming cirrus ice.

Case 1: Southern Flight

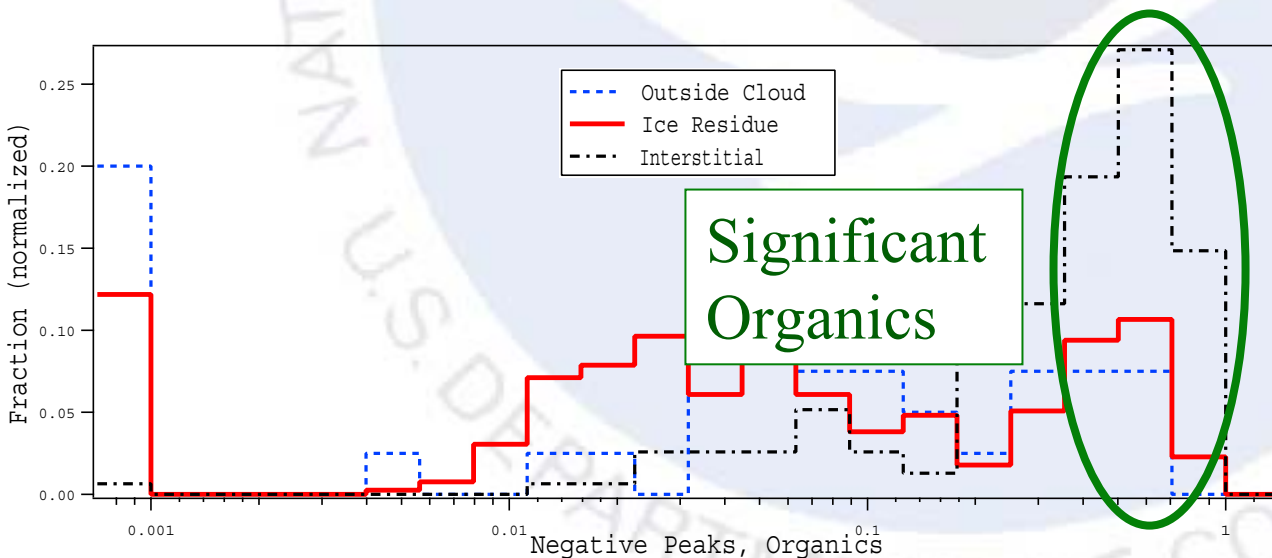


- Histogram of the area of the sodium peak in each positive polarity mass spectrum.
- This area can be used as a rough indicator of particle type.
- Most IR, particles outside cloud, and interstitial aerosols are *sulfate / organics : homogeneous freezing*.

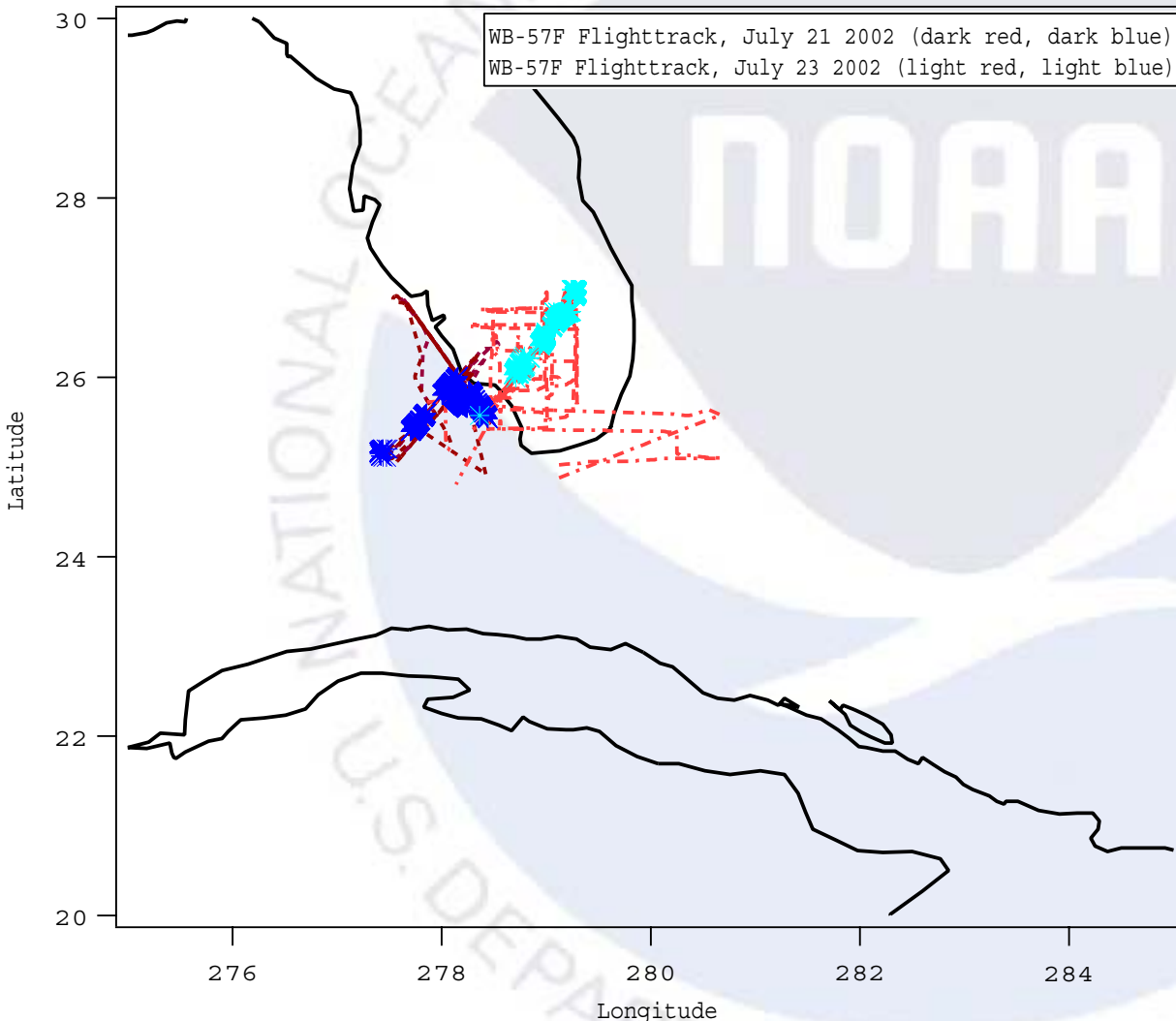
Case 1: Southern Flight



- Particles outside of cloud and IR contain considerable sulfate.
- Unactivated interstitial particles contain less sulfate but more organics.
- ‘Fractionation’ of particle composition during *homogeneous freezing*.

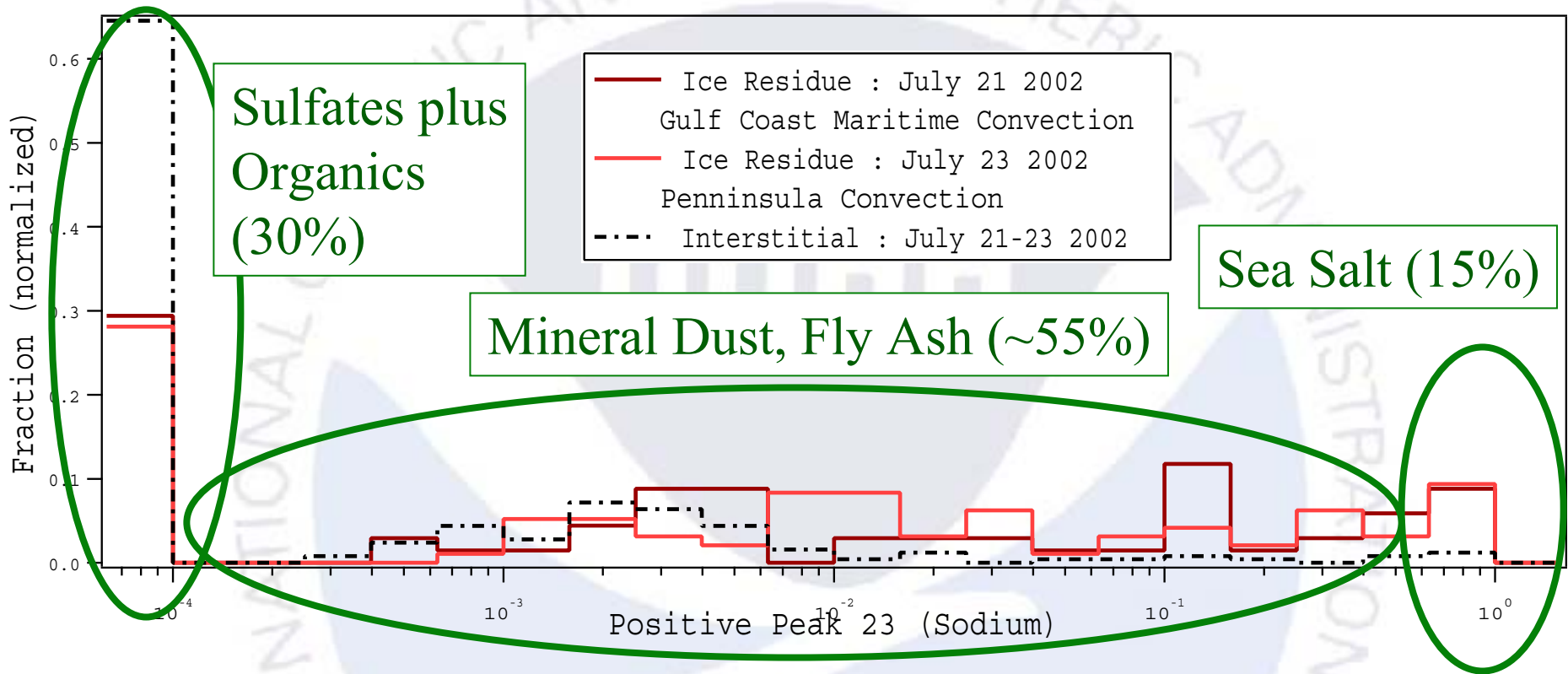


Three Case Studies: 2



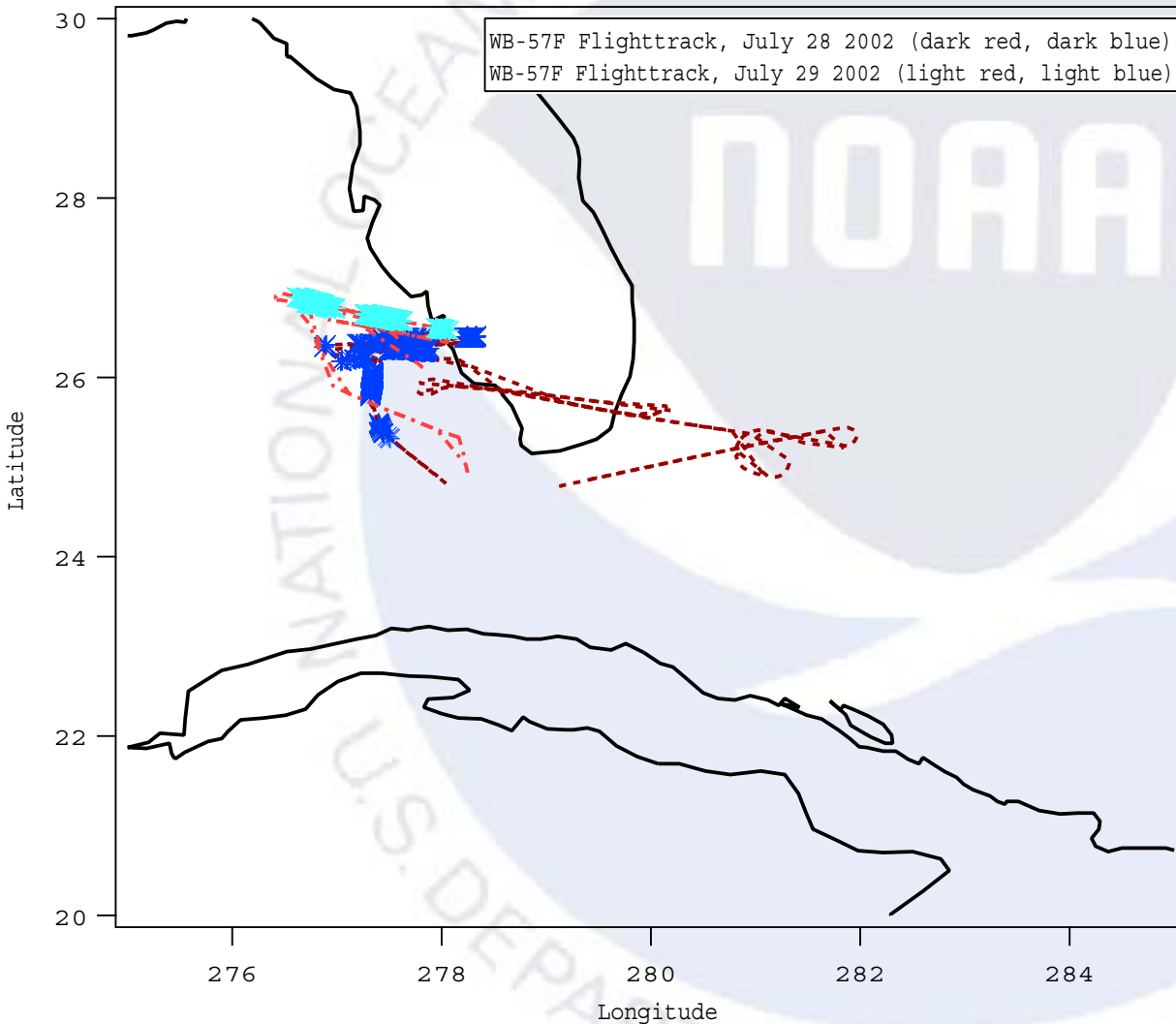
- Florida area convection, *'Moderate Dust'* on July 21-23 2002.
- Convection along gulf coast and peninsula (most data FL 400 - 450).
- Spectra from ~16 different cirrus events over two flights

Case 2: Moderate Dust



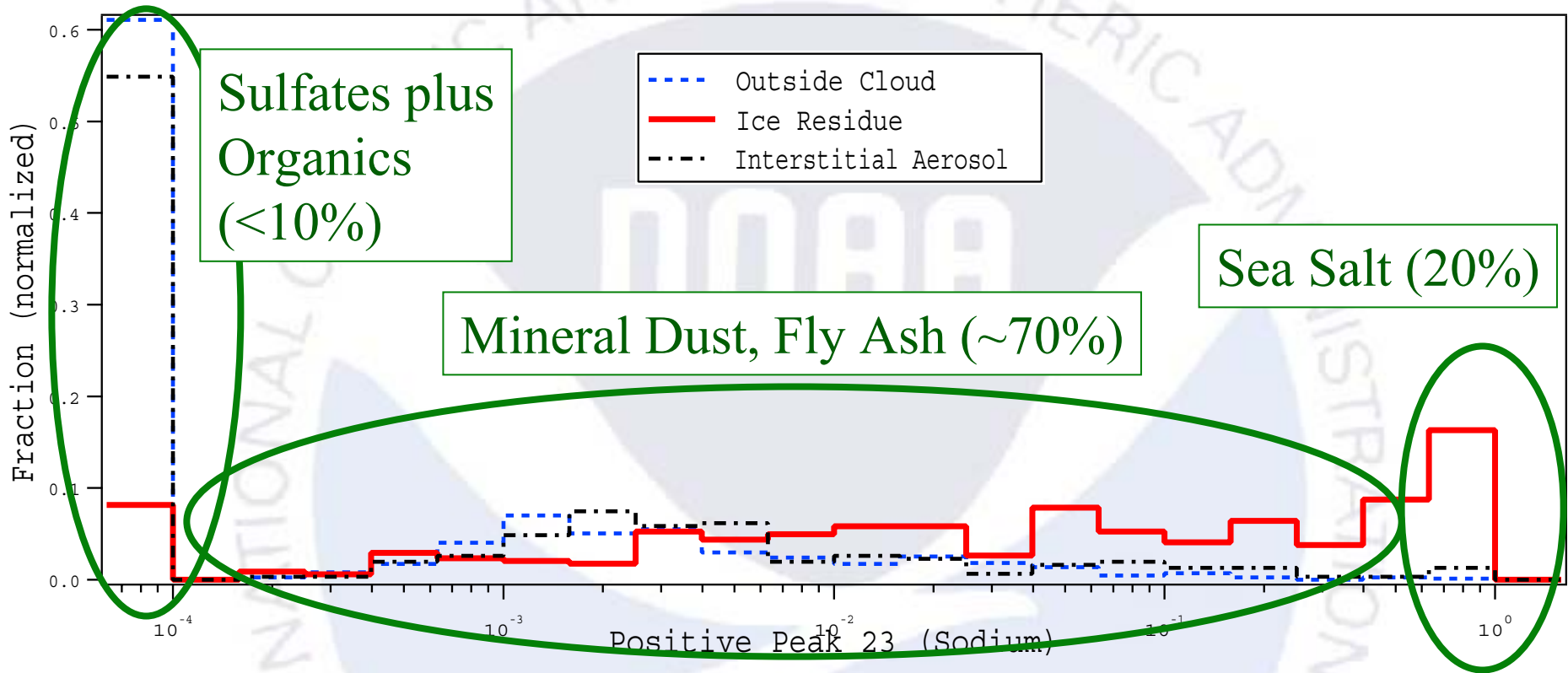
- Considerable sea salt as IR but a much smaller fraction (15%) than on 07072002 (not shown, 30%). Sulfates and organics ~30%.
- No significant difference between over-water and over-peninsula flights.
- Free tropospheric aerosol is typical sulfate / organic mix.
- A considerable fraction of IR of crustal or fly ash origin (~55%).

Three Case Studies: 3



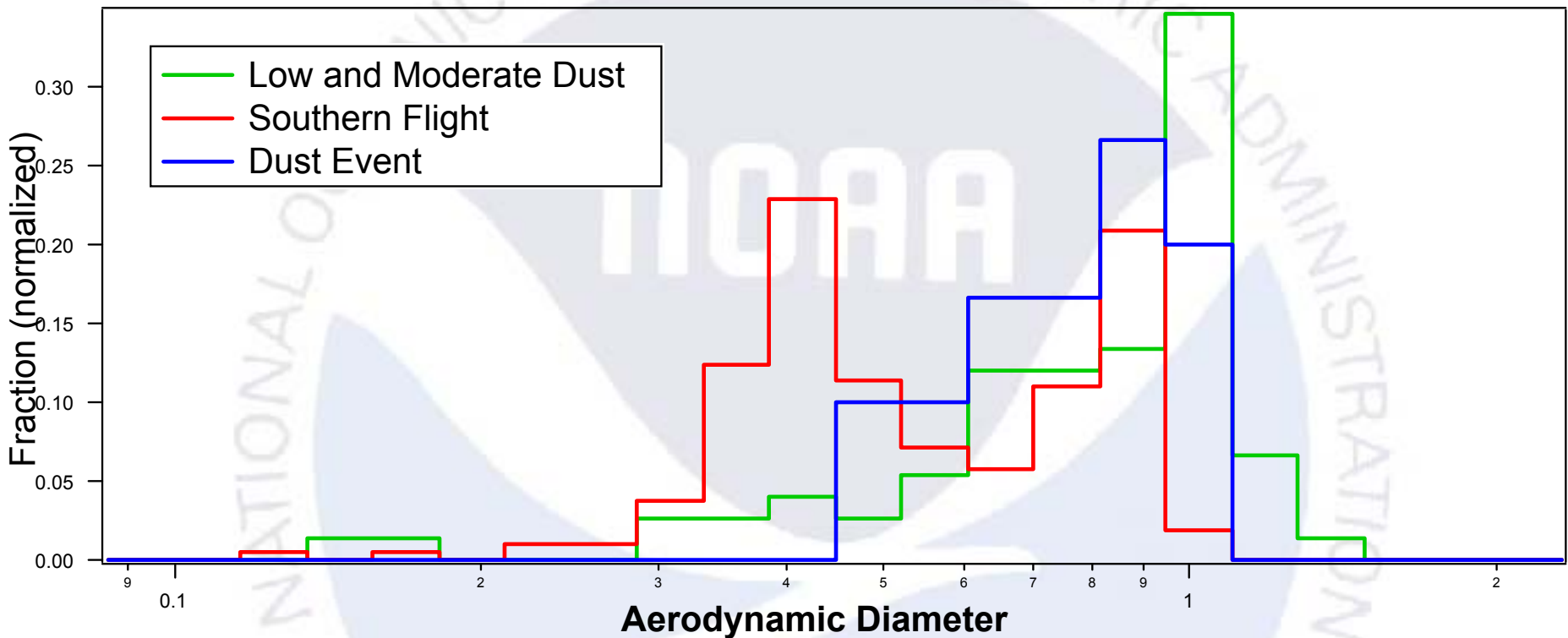
- Florida area convection, '*Dust Event*' July 28-29 2002.
- Convection along gulf coast (most data FL 400 - 440).
- Spectra from ~12 different cirrus over two flights.

Case 3: Dust Event



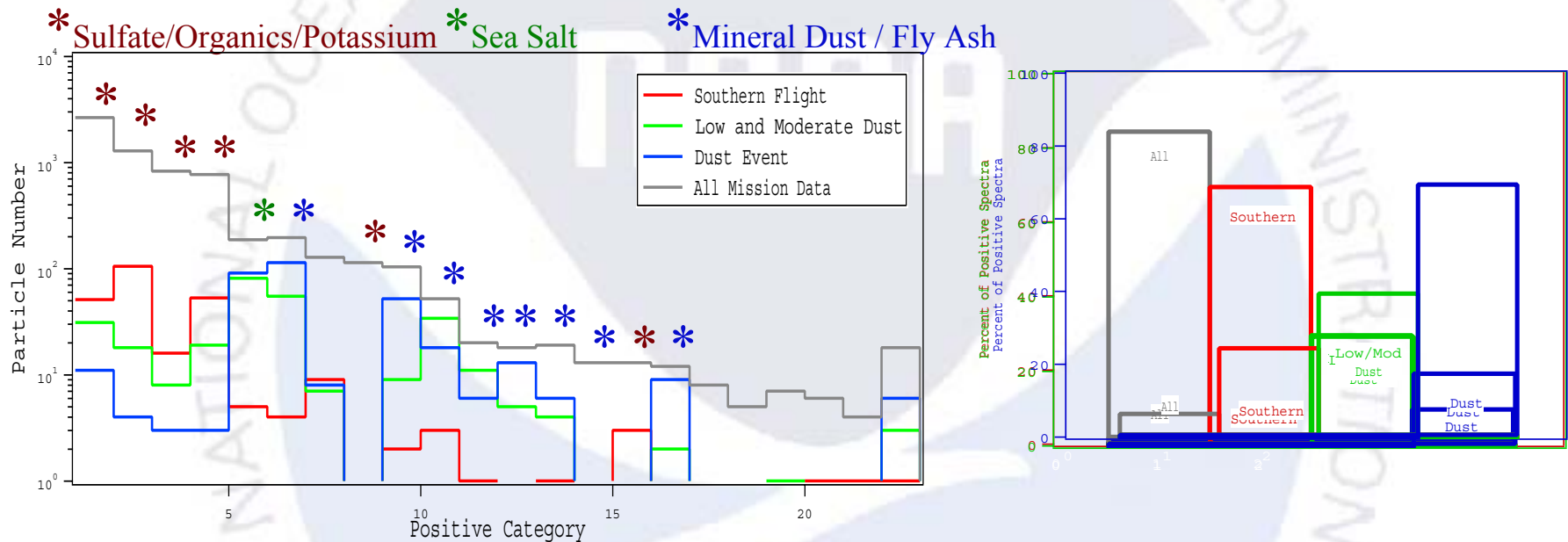
- Ice residue from July 28 -29 2002 have a much higher sodium signal than out of cloud particles or interstitial aerosol.
- ~20% are consistent with frozen sea salt. <10% Sulfates and organics.
- Most of the remainder (70%) are consistent with mineral dust or fly ash - *heterogeneous freezing...*

Ice Residual Size Distribution



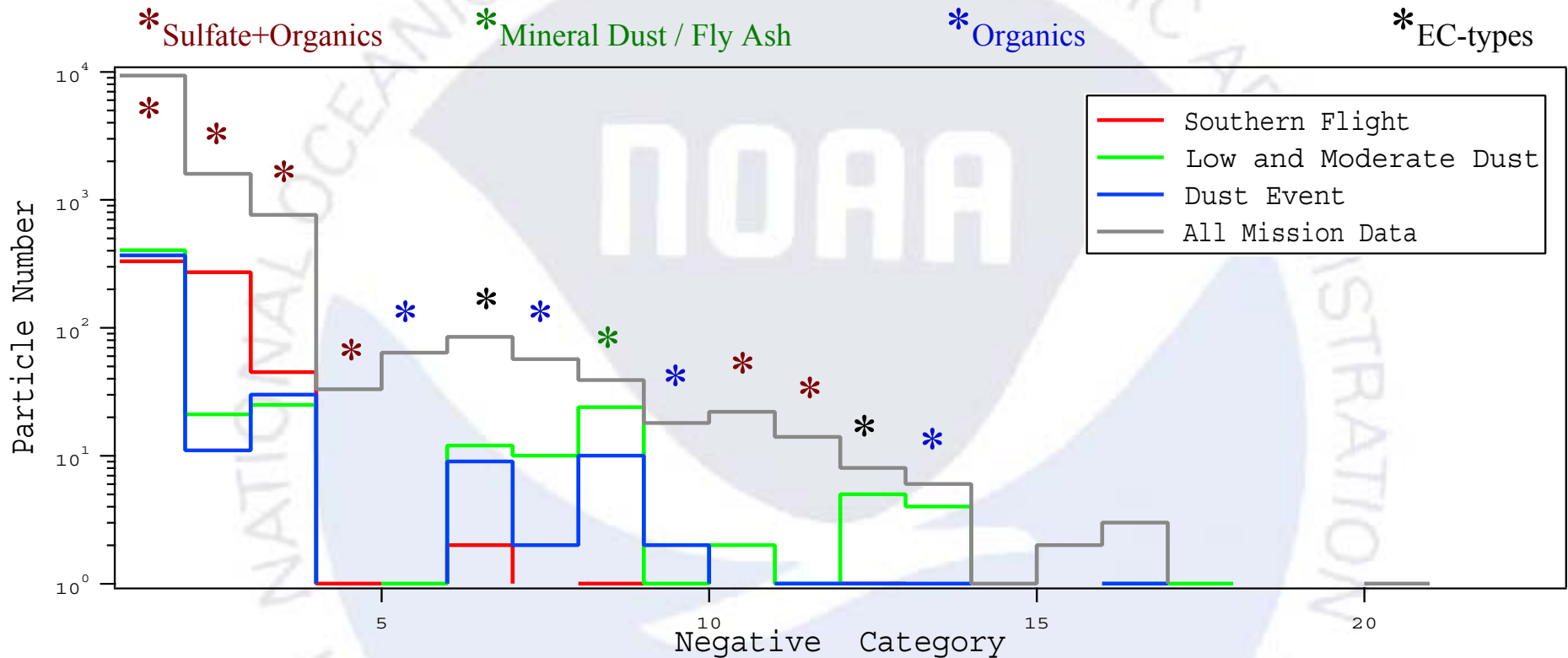
- The IR in the Florida area was larger than on the southern flight, consistent with sea salt and mineral dust / fly ash initiating freezing.
- IR on the southern flight contained a large mode consistent with mixed origin tropospheric particles and smaller tropopause particles.

Positive Polarity Categories



- In positive polarity, the majority of the particles analyzed during the mission were mixed sulfates/organics/potassium.
- The IR on the southern flight were roughly consistent with the 'All Mission Data' whereas those sampled in the Florida area were not.
- IR in the Florida area show enhancements in sea salt and mineral dust / fly ash - notably on the dust event flights.

Negative Polarity Categories



- In negative polarity, the majority of the particles analyzed during the mission were mixed sulfates/organics.
- Mineral dust / fly ash and elemental carbon (EC) were *enhanced* in the Florida area.
- Organics, notably category 6, were *depleted* in all IR types.

Conclusions

- The cirrus cloud sampled during the first *southern flight* was consistent with homogeneous freezing of the background aerosol with **a) input from stratospheric particles** with **b) higher organic content aerosols preferentially excluded** from IR.
- Ice Residue sampled on *moderate dust days* were 30% sulfate/organics, ~15% sea salt, and ~55% mineral dust /fly ash composition.
- Ice Residue sampled during the *dust event* on the last two flights were dominated by particles consistent with a **mineral dust / fly ash** origin .

Future Work

- Take a more in-depth look at flight-to-flight variability and particle differences.
- Elucidate the effect of organics on ice nucleation during CRYSTAL-FACE.
- What role did the presence of mineral dust play in the structure of the cirrus being sampled (crystal sizes, densities, etc.)?
- In depth discussions with other researchers.

Acknowledgements

- NASA and NOAA Funding
- Darrel Baumgardner for the CAPS data and Paul DeMott for useful discussions.
- Mission management and the air and ground crews of the WB-57F without whom this mission would not have been possible.